Condensed

ASSEMBLING AND USING YOUR . . . . .

Heathkit

TELEVISION ALIGNMENT GENERATOR

MODEL TS-4

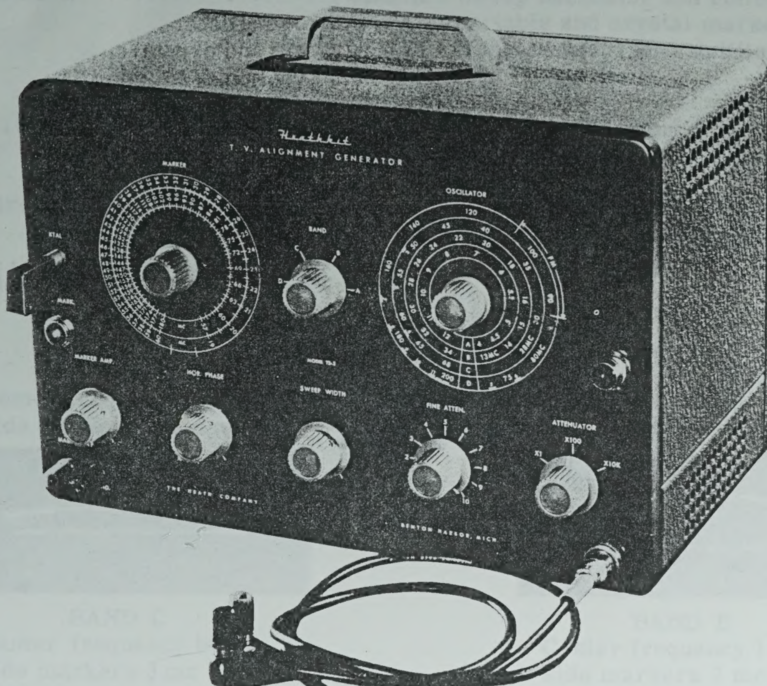
595-77

HEATH COMPANY
BENTON HARBOR,
MICHIGAN

PRICE $1.00

THE WORLD'S Finest TEST EQUIPMENT IN KIT FORM

HEATHKIT
TELEVISION ALIGNMENT GENERATOR
MODEL TS-4



SPECIFICATIONS

Frequency Range and Output............ Band A; 3.6 mc to 10 mc, output .23 volts RMS ±1/2 db
Band B; 10 mc to 26 mc, output .22 volts RMS ±1/4 db
Band C; 30 mc to 80 mc, output .11 volts RMS ±1/2 db
Band D; 80 mc to 220 mc, output .08 volts RMS ±3/4 db

(Output measured with H-P 410B high frequency VTVM. Readings taken directly from scale without compensation for pulse nature of output. DB readings taken for worst deviation on each band at a fixed center frequency.)

Output Impedance........................ 50 Ω, terminated at both ends of output cable.

Sweep Deviation........................ Continuously variable from 0-4 mc lowest maximum deviation, 0-42 mc highest maximum sweep, depending on frequency.

Fixed Frequency Marker................ 4.5 mc crystal, included with kit. Other frequency crystals may be quickly substituted if desired.

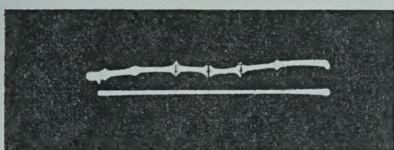
Variable Frequency Marker............ 19 mc to 60 mc on fundamentals, 57 mc to 180 mc on calibrated harmonics. Calibrated against furnished crystal which determines marker accuracy.

External Marker........................ Any RF frequency can be mixed with crystal and variable marker oscillators to provide as many as three marker pips on one trace. Marker energy can be taken out from external connector for separate applications.

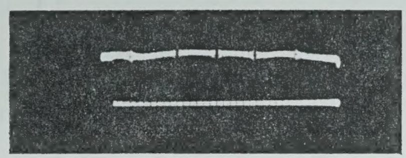
Attenuators	Step and "fine" controls for sweep oscillator, separate control for marker amplitude. Both sweep and marker output attenuated together by step switch to avoid marker overloading.
Blanking	2-way blanking incorporated to eliminate return trace.
Phasing	Narrow range phasing control to insure alignment accuracy.
Tube Complement	6BQ7A - sweep oscillator and buffer 12AT7 - variable and crystal marker oscillator 12AX7 - blanking and AGC amplifier 6CL6 - shunt regulator 6X4 - rectifier
Cables	Output cable, scope horizontal cable and compensated scope vertical cable provided. Convenient pod termination used on output cable.
Power Requirements	110 volt AC 50/60 cycle, 50 watts
Dimensions	13" wide x 8 1/2" high x 7" deep
Net Weight	11 lbs.
Shipping Weight	16 lbs.

FREQUENCY LINEARITY

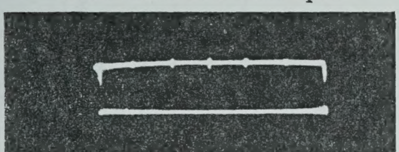
BAND A
Center frequency 6.5 mc, side markers 1 mc apart.



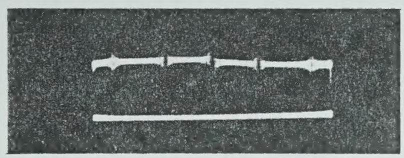
BAND B
Center frequency 16 mc, side markers 2 mc apart.



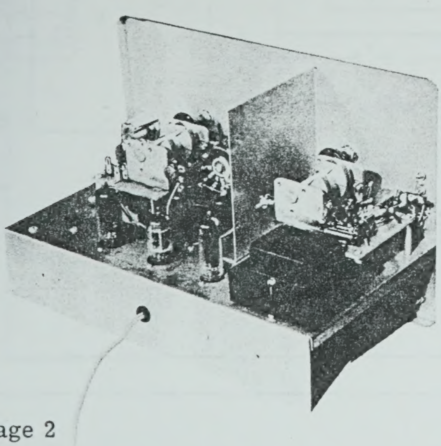
BAND C
Center frequency 50 mc, side markers 3 mc apart.

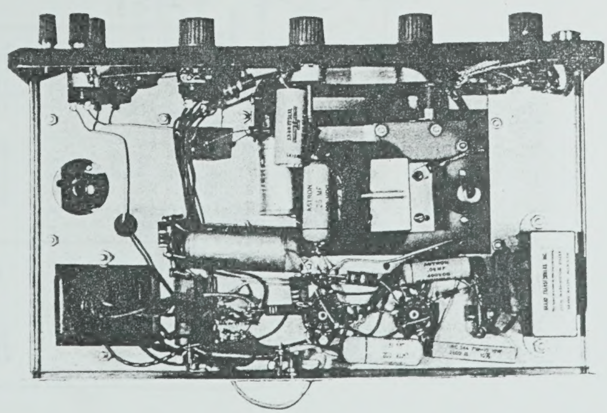


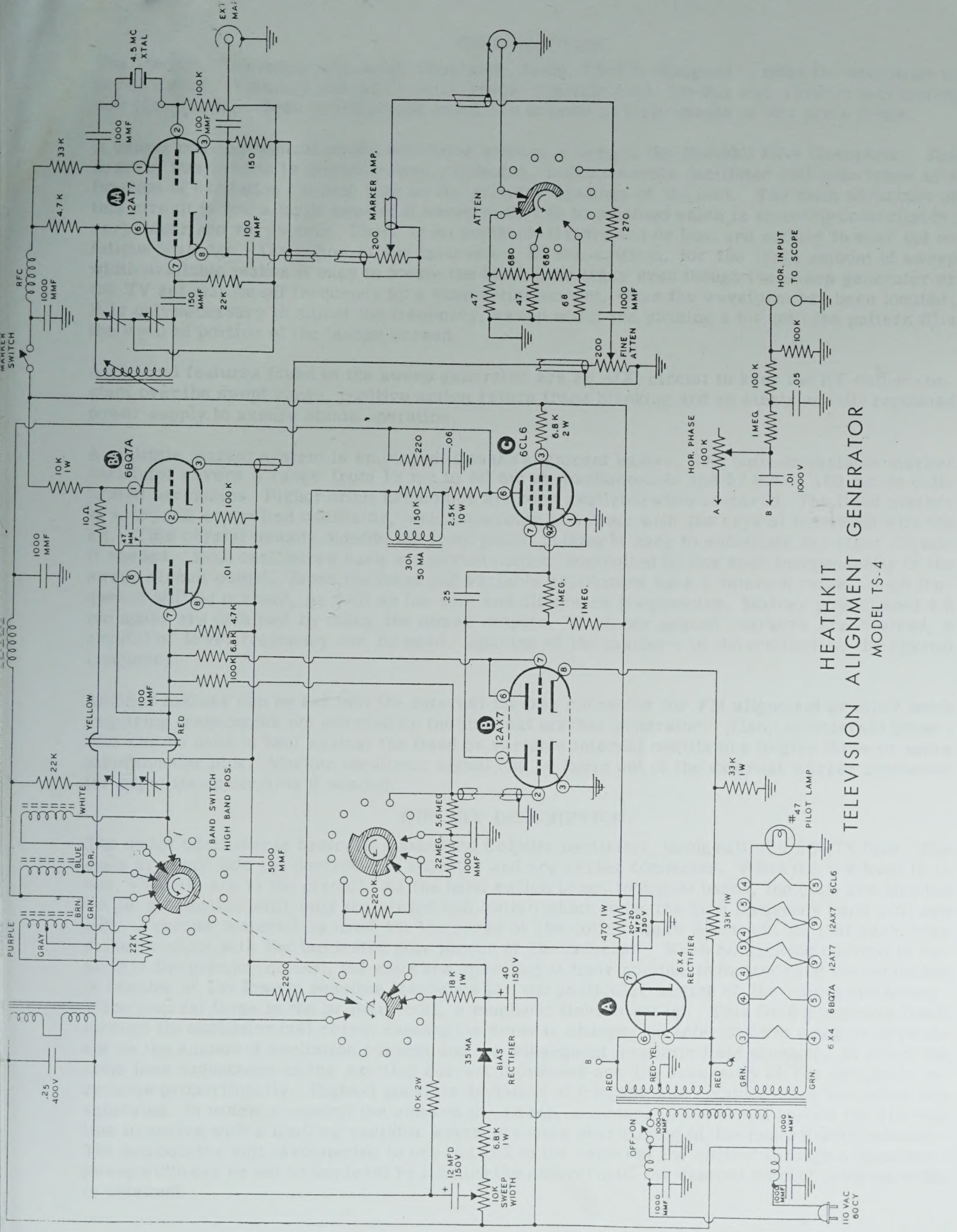
BAND D
Center frequency 140 mc, side markers 2 mc apart.



All pictures taken with the oscillator dial approximately at the mid-range position. Sweep width adjusted to show only easily identifiable markers.







HEATHKIT
TELEVISION ALIGNMENT GENERATOR
MODEL TS-4

INTRODUCTION

The Heathkit Television Alignment Generator, model TS-4 is designed to offer the maximum in performance, flexibility and utility at the lowest possible cost. To this end, several outstanding new features have been incorporated which are unusual in instruments in this price range.

A unique non-mechanical sweep oscillator system is used in the Heathkit TS-4 Generator. The heart of this system is the controllable inductor, which controls oscillator coil inductance as a function of excitation current flow in the primary windings of the unit. The main advantage of this circuit is that a large amount of sweep width can be obtained which is smoothly controllable, very linear and very stable. There is no mechanical vibration or hum and nothing to wear out or fatigue with age. Operation of the instrument is non-critical, for the large amount of sweep width available makes it easy to locate the band-pass trace even though the sweep generator or the TV set may be off frequency by a substantial amount. Once the waveform has been located, it is only necessary to adjust the frequency, sweep width and phasing a bit until the pattern fills the desired portion of the 'scope screen.

Additional features found in the sweep generator are an AGC circuit to keep the RF output constant over the swept range, positive action return trace blanking and an electronically regulated power supply to assure stable operation.

A multiple marker system is employed to make alignment easier. The built-in variable marker oscillator covers a range from 19 mc to 60 mc on fundamentals and 57 mc to 180 mc on calibrated harmonics. Higher order harmonics are also available when required. The fixed marker is a crystal controlled oscillator, which operates at 4.5 mc with the crystal furnished with the kit. This crystal mounts outside the front panel, making it easy to substitute any other crystal if needed. Both oscillators have a common output, controlled by one knob independently of the sweep circuit output. Since the fixed and variable oscillators have a common output, each frequency will be present, as well as the sum and difference frequencies. Marker pips spaced 4.5 mc apart are obtained by using the mixed outputs. If closer spaced markers are desired, a crystal of lower frequency can be used. Spacing of the markers is determined by the crystal frequency.

Another marker can be fed into the external marker connector for FM alignment or other work requiring frequencies not covered by the internal marker generator. Also, an external generator can be used to beat against the fixed or variable internal oscillators to give three or more simultaneous pips. Marker oscillator signal can be taken out of the external marker connector for separate application if needed.

CIRCUIT DESCRIPTION

The swept oscillator is basically a standard Colpitts oscillator, using half of a 6BQ7A tube. The coils are built into the controllable inductor and are series connected. When the low band is in use, all coils are in the circuit. As the band switch is set to higher bands, the coils are shorted out in succession until only the straps and switch which form the high frequency band coil are left. Ferrous material is used for the cores of the coils, which are made so that each core makes contact with the laminated pole pieces of the inductor. When no exciting current is applied to the primary circuit, the coils are operating at their nominal inductance and the oscillator is running at the lowest possible frequency for the particular setting of the tuning condenser. When current flows in the primary coil, a magnetic field is set up. This field completes itself through the oscillator coil cores, causing the cores to change characteristics to a degree dependent on the amount of excitation current and the subsequent magnetic field strength. In effect the coils lose inductance as the exciting current increases and the frequency of the oscillator increases proportionally. Highest possible deviation of frequency is obtained when the cores are saturated. In order to control the width of the sweep, a control is connected across the 110 volt line in series with a limiting resistor which prevents overloading of the controllable inductor. The Increductor unit is connected to one end and to the center of the control through a capacitor. Sweep width can be set to any level by rotating the control until the desired amount of sweep width is obtained.

INTRODUCTION

The Heathkit Television Alignment Generator, model TE-4 is designed to offer the maximum in quality, flexibility and utility at the lowest possible cost. To this end, several outstanding new features have been incorporated which are unusual in instruments in this price range.

A unique non-mechanical sweep oscillator system is used in the Heathkit TE-4 Generator. The heart of this system is the controllable inductor, whose oscillator coil inductance varies as a function of saturation current flow in the primary windings of the unit. The main advantage of this system is that large amounts of sweep width can be obtained which is smoothly controllable, very linear and very stable. There is no mechanical vibration or hum and nothing to wear out or become worn out. Operation of the instrument is non-critical, for the large amount of sweep width available makes it easy to locate the band-pass curve even though the sweep generator or the I.F. may be off frequency by a substantial amount. Once the waveform has been located it is only necessary to adjust the frequency, sweep width and phasing a bit until the pattern fills the desired portion of the scope screen.

Additional features found in the sweep generator are an AGC circuit to keep the RF output constant over the sweep range, positive action retrace blanking and an electronically regulated power supply to assure stable operation.

A multiple marker system is employed to make alignment easier. The built-in variable marker oscillator covers a range from 19 mc to 60 mc on fundamentals and 57 mc to 180 mc on calibrated harmonics. Higher order harmonics are also available [illegible]. The fixed marker is a crystal controlled oscillator, which operates at 4.5 mc with the crystal furnished with the kit. This crystal mounts outside the front panel, making it easy to substitute any other crystal if needed. Both oscillators have a common output, controlled by the same attenuator at the marker circuit output. Since the fixed and variable oscillators have a common output, each frequency will be present, as well as the sum and difference frequencies. Marker pips spaced 4.5 mc apart are obtained by using the mixed outputs. If closer spaced markers are desired, a crystal of lower frequency can be used. Spacing of the markers is determined by the crystal frequency.

Another feature can be found in the external marker connector for FM alignment or other work requiring frequencies not covered by the internal marker generators. Also, an external generator can be used to beat against the fixed or variable marker oscillators to give three or more simultaneous pips. Marker oscillator signal can be taken out at the external marker connector for separate application if needed.

GENERAL DESCRIPTION

The sweep oscillator is basically a standard Colpitts oscillator [illegible]. The coils are built into the controllable inductor and are [illegible]. When [illegible] the band switch is set to [illegible] [illegible]

Center frequency sweep is obtained by biasing the windings of the controllable inductor with DC current. The current is adjusted on each band so that at zero sweep width, the operating frequency is halfway between the no-current and the saturation point of the inductor. When the band switch is turned to a different band, it will change the amount of current, thus assuring good linearity at all frequencies. Bias current is obtained from the small selenium rectifier connected to one side of the AC line. The circuit is completed through an 18 KΩ resistor, a 10 KΩ resistor and the primary windings of the Increductor unit. A 40 μfd filter condenser is used to smooth out the current. Sweep is obtained by coupling AC through the 12 μfd isolating capacitor, which varies the primary current without changing the static or center current supplied by the rectifier. Changes in current for different bands are accomplished by switch shunting the 18 KΩ bleeder resistor. Oscillator operation is entirely on fundamentals, insuring adequate output on all bands and efficient attenuator action.

The second half of the 6BQ7A sweep oscillator is connected as a cathode follower. RF energy is coupled from the grid circuit of the oscillator to the grid of the cathode follower. A cathode follower is a high impedance input device, so loading effects on the oscillator are negligible. Output from the cathode follower is at low impedance and is connected to the attenuator network.

Blanking is required to eliminate the return trace encountered when the oscillator returns to the starting point. Without blanking, a double trace is present which is difficult to interpret. Elimination of the return trace is accomplished by cutting down the B+ voltage to the oscillator tube and at the same time driving the oscillator grid highly negative. B+ voltage is reduced due to a portion of the negative grid blanking voltage fed to the regulating amplifier. This causes the shunt regulator tube to conduct heavily during the blanking time. The subsequent large drop across the shunt regulator load resistor and choke effectively cuts off the high voltage to the sweep oscillator tube. Negative voltage at the oscillator grid is applied from one half of the 12AX7 blanking and regulator amplifier. The grid and plate are tied together and to the oscillator grid through a 6.8 KΩ isolating resistor. One side of the power transformer high voltage secondary is tied to the cathode of the blanking tube through a voltage dividing network of two 33 KΩ resistors. When the cathode swings in a positive direction, the plate is negative in respect to the cathode and no current can flow. At this time, the oscillator will be operating with its own 4.7 KΩ grid leak only. During the negative half of the cycle at the cathode of the blanking tube, the grid and plate become effectively positive in respect to the cathode and current will flow. The plate will follow the cathode causing a high negative voltage to be applied to the oscillator grid, cutting the tube off.

Regulation of the RF output voltage is accomplished by feeding a portion of the DC voltage developed at the oscillator grid through an isolating resistor to the control grid of the regulating amplifier. Any variations in oscillator output are amplified and fed through a resistor and capacitor to the grid of the 6CL6 shunt regulator. A unique direct coupling system is used at this point, which allows the shunt regulator to handle wide voltage swings without distortion. The oscillator plate is connected through an RF filter to the plate of the 6CL6. A resistor and choke are also connected to this plate. Any variation in current will cause a related increase or decrease of B+ voltage at this point and thus the oscillator high voltage is varied. If oscillator output increases, the negative voltage at the grid will also increase. A negative voltage at the grid of the regulator amplifier will be fed to the grid of the 6CL6 as a positive potential, causing an increase in plate current. This in turn is reflected in reduced plate voltage, which is reflected to the oscillator plate causing the output to drop. An opposite reaction occurs if the output of the oscillator should decrease.

Changes of oscillator efficiency on different bands are compensated for by switching bias voltage to the grid of the regulator amplifier. Efficiency on band "D" is low, and the voltage from the oscillator grid is fed straight though without compensation. Better efficiency is evident on band "C" and a slight amount of positive voltage is added through the switch to keep the regulator operating in its optimum range. Highest operating efficiency is obtained on bands "A" and "B" and the same higher positive potential is applied for both.

A 12AT7 dual triode tube is used in the multiple marker system. One half of the tube is employed as a Colpitts variable frequency oscillator, covering a fundamental range from 19 mc to 60 mc. Slug tuning is used in the coil so the oscillator can be trimmed and padded for perfect tracking over the entire frequency range. Output from the oscillator is taken from the cathode circuit at low impedance so that changes of control settings and loading will not affect stability. The second half of the 12AT7 is a Pierce crystal oscillator and the output of this section is taken from the same cathode load as the first. Mixing the output of the two oscillators in a common load causes the frequencies of both generators to be present, as well as the sum and difference of the frequencies and their harmonics. Therefore, a 4.5 mc crystal mixed with the variable oscillator at an example frequency of 25 mc will give markers at 25 mc, 29 1/2 mc, 20 1/2 mc, 34 mc, 16 mc, etc. and at 22 1/2 mc and 27 mc, which are direct harmonics of the crystal oscillator. Other frequency crystals can be substituted to obtain markers that are closer or further spaced, or to give direct frequency check points. Additional markers are obtained by connecting a signal generator to the EXT. MARK. connector.

RF energy from the cathode of the marker generator is taken out through a DC blocking capacitor to a control. Output from the control is connected to the input of the step attenuator network for the sweep oscillator. This causes the output of the marker to be attenuated proportionally in respect to the sweep signal, preventing excessive marker overloading, but still allowing a wide range of amplitude control to be maintained.

The power supply employs a 6X4 full wave rectifier with well filtered DC output. Plate voltage for the rectifier and filament voltage for all tubes is furnished by the power transformer, as well as voltage for the phasing and blanking circuits. Phasing is accomplished by connecting a condenser and variable resistor across the high voltage plate windings. Changing the amount of resistance changes the phase shift in the network, which is connected to the horizontal output terminals.

Calibration of the TS-4 Television Alignment Generator is easily accomplished, for an accurate reference is furnished with the kit, (the 4.5 mc crystal). Harmonics of the 4.5 mc crystal are used to calibrate the variable frequency marker oscillator at several points on the dial. Adjustment of pointer setting and slug tuning effectively trims and pads the oscillator so that it tracks over the entire dial range. The sweep oscillator dial needs only to be indexed with the condenser plates fully meshed, for accuracy is not required from the sweep portion of the instrument. The marker system is always considered to be the accurate reference, not the sweep system. Frequency markings on the sweep dial are for reference only.

NOTES ON ASSEMBLY AND WIRING

The Heathkit Television Alignment Generator model TS-4, when constructed in accordance with the instructions in the manual, is a high-quality instrument capable of many years of trouble-free service. We therefore urge you to take the necessary time to assemble and wire the kit carefully. Do not hurry the work and you will be rewarded with a greater sense of confidence, both in your instrument and your own ability.

This manual is supplied to assist you in every way to complete the instrument with the least possible chance for error. We suggest that you take a few minutes now and read the entire manual through before any work is started. This will enable you to proceed with the work much faster when construction is started. The large fold-in pictorials are handy to attach to the wall above your work space. Their use will greatly simplify the completion of the kit. These diagrams are repeated in smaller form within the manual. We suggest that you retain the manual in your files for future reference, both in the use of the instrument and for its maintenance.

UNPACK THE KIT CAREFULLY AND CHECK EACH PART AGAINST THE PARTS LIST. In so doing, you will become acquainted with each part. Refer to the charts and other information shown on the inside covers of the manual to help you identify any parts about which there may be a question. If some shortage is found in checking the parts, please notify us promptly and return the inspection slip with your letter to us. Hardware items are counted by weight and if a few are missing, please obtain them locally if at all possible.

CAUTION: The controllable inductor, the variable condensers and the crystal are quite delicate and should be handled with care. The tuning condensers should be kept fully meshed until construction is completed, to avoid bending the plates. The crystal can be damaged by a sharp blow of any kind, so it should be placed where it will not be disturbed or accidentally dropped. Many short leads come out of the controllable inductor unit which may be broken off if the unit is handled excessively. It is recommended that the unit be placed in a safe location until it is ready to be installed in the instrument.

Read the note on soldering on the inside of the back cover. Crimp all leads tightly to the terminal before soldering. Be sure both the lead and the terminal are free of wax, corrosion or other foreign substances. Use only the best rosin core solder, preferably a type containing the new activated fluxes such as Kester "Resin-Five," Ersin "Multicore" or similar types.

NOTE: ALL GUARANTEES ARE VOIDED AND WE WILL NOT REPAIR OR SERVICE INSTRUMENTS IN WHICH ACID CORE SOLDER OR PASTE FLUXES HAVE BEEN USED. WHEN IN DOUBT ABOUT SOLDER, IT IS RECOMMENDED THAT A NEW ROLL PLAINLY MARKED "ROSIN CORE RADIO SOLDER" BE PURCHASED.

Resistors and controls generally have a tolerance rating of ±20% unless otherwise stated in the parts list. Therefore a 100 KΩ resistor may test anywhere from 80 KΩ to 120 KΩ. (The letter K is commonly used to designate a multiplier of 1000.) Tolerances on condensers are generally even greater. Limits of +100% and -50% are common for electrolytic condensers. The parts furnished with your Heathkit have been specified so as to not adversely affect the operation of the finished instrument.

In order to expedite delivery to you, we are occasionally forced to make minor substitutions of parts. Such substitutions are carefully checked before they are approved and the parts supplied will work satisfactorily. By checking the parts list for resistors, for example, you may find that a 120 KΩ resistor has been supplied in place of a 100 KΩ as shown in the parts list. These changes are self-evident and are mentioned here only to prevent confusion in checking the contents of your kit.

We strongly urge that you follow the wiring and parts layout shown in this manual. The position of wires and parts is very critical in this instrument and changes may seriously affect the characteristics of the circuit.

STEP-BY-STEP ASSEMBLY INSTRUCTIONS

THE HEATHKIT TS-4 TELEVISION ALIGNMENT GENERATOR IS A COMPLEX INSTRUMENT CONTAINING SEVERAL SUB-ASSEMBLIES. WE VERY STRONGLY URGE THAT THE STEP-BY-STEP INSTRUCTIONS BE FOLLOWED EXACTLY, RATHER THAN WIRING FROM THE PICTORIALS AND SCHEMATIC EXCLUSIVELY. SPECIAL INSTRUCTIONS REGARDING SEQUENCE OF ASSEMBLY AND LEAD LENGTHS ARE GIVEN TO MAKE CONSTRUCTION OF THE KIT AS EASY AS POSSIBLE. WIRING AND MOUNTING OF PARTS IN IMPROPER ORDER MAY RESULT IN THE NECESSITY OF RE-DOING WORK PREVIOUSLY ACCOMPLISHED.

The following instructions are presented in a simple, logical, step-by-step sequence to enable you to complete your kit with the least possible confusion. Be sure to read each step all the way through <u>before</u> you start to do it. When the step is completed, check it off in the space provided.

We suggest you do the following before any work is started:

1. Attach the large fold-in pictorials to the wall above your work bench.
2. Go through the entire assembly and wiring instructions. This is an excellent time to read the entire instruction section through and familiarize yourself with the procedure.
3. Lay out all parts so that they are readily available. Refer to the general information inside the front and back covers of this manual to help you identify components.

TESTING THE COMPLETED INSTRUMENT

If an ohmmeter is available, check the DC resistance between pin 7 of 6X4 socket A and ground. The resistance should be at least 20,000 ohms after one minute. If lower, carefully recheck wiring for an error. Give special attention to the connections around the 6X4 socket, the filter condenser, terminal strips H and BP and 6CL6 socket C.

Make sure that the line switch is off by rotating the HOR. PHASE control to its full counterclockwise position. Connect the line cord to a 105-125 volt 50/60 cycle AC outlet. DO NOT CONNECT THIS INSTRUMENT TO A DC (DIRECT CURRENT) LINE. SERIOUS DAMAGE TO THE POWER TRANSFORMER WILL RESULT. Do not attempt to use this instrument on a 25 cycle AC source, for it will not operate and the transformer may be damaged.

Turn the instrument on by rotating the HOR. PHASE control clockwise until a click is heard. The filaments of all tubes should light. Now insert the 6X4 rectifier tube in its socket. The filaments should light. Observe the metal elements in the tube to make sure that they remain dark colored. A red glow from the plates of the rectifier indicates the existence of a short circuit somewhere in the B+ circuit and further checks will be necessary to locate the trouble.

ALIGNMENT OF THE INSTRUMENT

Calibration of the marker generator is easily accomplished, for an accurate calibration reference is furnished with the kit. Connect the terminated output lead to the EXT. MARKER post on the front panel. The opposite end of this cable should be connected to the RF probe of a signal tracer or the demodulator probe of an oscilloscope. If neither of these is available, any amplifier or oscilloscope can be used with a crystal diode in series with the input lead. Plug the 4.5 mc crystal into the XTAL socket. Turn the instrument on and rotate the MARKER AMP. control fully clockwise. Set the indicator to 22.5 mc (the fifth harmonic of the crystal) and adjust the marker oscillator coil slug until a beat note or squeal is heard, or a fuzzy trace appears on the oscilloscope with the 'scope gain at maximum if an oscilloscope is used. Next, set the dial to 27 mc (the sixth harmonic). A beat note should again be evident. The next check points should be at 31.5 mc and 36 mc. If the beat notes occur at frequencies other than those indicated slip the pointer slightly on the shaft and again adjust the marker coil slug. This effectively trims and pads the oscillator to get it to track with the dial markings. It may be necessary to repeat this operation several times to obtain the desired degree of accuracy. If the error should become worse, slip the indicator on the shaft in the opposite direction a small amount at a time until the marker tracks properly. If it is impossible to obtain satisfactory tracking, there is a chance that the oscillator is beating against the wrong harmonic of the crystal. To correct this condition, set the indicator to 22.5 mc once again. Adjust the oscillator coil slug until a beat is heard that is a different one than originally obtained. Then, repeat the operations described above. Once the beats occur at the proper places, the oscillator is correctly calibrated. In general, the slug will be fairly well into the coil when proper calibration is obtained.

In some rare instances, it may be difficult or impossible to properly calibrate the marker oscillator due to a shift of tuning condenser calibration, which may have been caused by handling in transit. Usually the errors will be rather minor, but then they can be cleared up entirely by making a very simple adjustment of the tuning condenser itself.

If it is impossible to obtain good tracking over the entire marker range, it would be advisable to set the dial to 54 mc and adjust the screw slightly until the beat note is evident. The dial should then be rotated to 58.5 to make sure that the right beat is being used. Once sure that the correct frequency has been obtained, move the dial lower in frequency until a discrepancy shows up. When an error does appear, it should be noted whether the dial reads high or low in frequency. If the dial reads high, it will be necessary to turn the condenser outward a little bit and bend the outside serrated plate outward slightly at the point where the frequency error was evident. Reset the condenser to the original setting to see whether or not the error is still present. By very gently pushing the outside plates outward, the gang can be effectively knifed until good accuracy is obtained. Of course, if the frequency reads low, it will be necessary to push the plates inward gently to get the same effect. After this discrepancy has been cleared up, the accuracy should be checked once again at the high end of the dial. When sure that everything is all right, the

tuning condenser should be set to a lower frequency until the next discrepancy, if any, appears. Again, a very minor adjustment of the plates will allow this point to be brought in tolerance. Continuing this procedure until the bottom frequency of 22.5 mc is calibrated will insure that a degree of accuracy better than 1% can be obtained over the entire range of the marker oscillator.

Fine calibration of the sweep oscillator dial is not necessary. This portion of the instrument is calibrated by indexing the pointer to the line to the right of band identification letters A, B, C and D with the tuning condenser plates fully meshed. Proper identification of the sweep frequency is accomplished by use of the marker generator.

Similarly, the SWEEP WIDTH control is not calibrated, for the markers will quickly reveal the band width of any circuit being aligned.

IMPORTANT NOTE: If the markers show up moving right to left when the marker frequency is increased, the blanking circuit is operating 180 degrees out of phase. This condition can be corrected quickly by simply reversing the black and black-red leads of the power transformer. These leads are connected to terminal strip T1 and tube socket A2.

Install the instrument in the cabinet, securing with self-tapping screws through the holes in the back.

OPERATION OF THE TS-4 TELEVISION ALIGNMENT GENERATOR

MARKER OSCILLATOR

An extremely versatile marker circuit is employed in the Heathkit Television Alignment Generator. It is capable of providing single, dual or multiple markers, depending upon the desire of the operator. The high output level of the variable marker oscillator makes it possible to use harmonics as well as fundamentals, thus greatly extending the usefulness of this section of the instrument.

The primary function of the marker oscillator is to give an accurate single frequency which can be used to identify portions of a bandpass waveform. This is accomplished by beating a portion of the marker oscillator output against the sweep oscillator output within the instrument. When the frequencies of the two oscillators approach the same point, the difference between the two frequencies will be within the audio range and will show up on the trace as a fuzzy line. If a wide band oscilloscope is used, this line will extend practically the full length of the trace, since most modern oscilloscopes are capable of reproducing frequencies up into the RF spectrum. In order to reduce the oscilloscope response and sharpen the marker pip, a specially compensated scope lead is furnished. This lead provides scope isolation preventing distortion of the trace as well as reducing the high frequency response.

To identify bandwidth of a tuned circuit, the marker pip is set to a point 30% down the slope of one side of the waveform and the frequency on the marker dial noted. The pip is then set to a point 30% down the opposite side and the frequency noted again. The difference between the two frequencies will be the bandwidth of the circuit under test.

When adjusting the bandpass waveform of a circuit, the marker is set to the high or low side of the waveform, depending on which is to be adjusted. The RF or IF transformer adjustment is then made until the waveform conforms to the manufacturer's specifications.

The crystal oscillator is designed so that the output of the crystal oscillator is mixed with the output of the variable marker oscillator in a common cathode resistor. This causes the crystal frequency and its harmonics to be present at the output also, as well as the mixed frequencies, which are the sum and difference of the crystal and variable oscillator outputs. Thus, if the variable marker is operating at 25 mc and the crystal is in its socket, the output frequencies will be 25 mc, 29.5 mc and 21.5 mc. Therefore, if the variable marker is set to the high or low side of a wide band IF or RF waveform, another marker will appear at a point 4.5 mc away on the opposite side of the waveform. Markers spaced farther apart or closer together can be obtained by substituting crystals of higher or lower frequency, respectively.

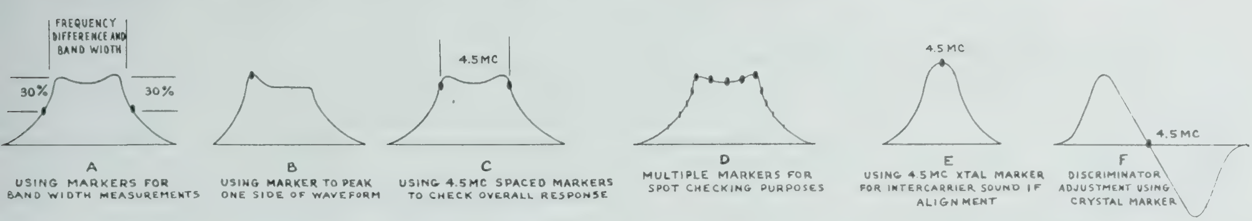
It must be remembered that the crystal operates on harmonics at these higher frequencies and so the 4.5 mc spaced markers will be much lower in amplitude than will the fundamental marker provided by the variable oscillator. Usually a good check can be obtained by moving the variable oscillator marker pip well down one side of the trace so that the marker gain can be turned up without distorting the trace. The other bandwidth marker will then show up clearly on the opposite side. Sometimes the bandwidth marker amplitude can be effectively increased by simply moving the variable marker to the opposite side of the trace. In some cases, the plus beat may be more evident than the minus beat or vice versa.

Many additional uses for the crystal marker exist. Direct crystal markers can be obtained by use of a crystal operating directly at the desired frequency or at a harmonically related lower frequency. The 4.5 mc crystal furnished with the kit is very useful as a signal generator for the alignment of the 4.5 mc sound IF encountered in intercarrier TV sets. It also provides a highly accurate marker when sweep techniques are used. For FM alignment purposes, a 10.7 mc or a 5.35 mc crystal can be used to give a highly accurate marker. Harmonics of a crystal of this frequency can also be used for FM RF alignment. The ninth and tenth harmonics of a 10.7 mc crystal both fall in the 88-108 mc FM spectrum. The 18th, 19th and 20th harmonics of a 5.35 mc crystal could be used in the same manner. Similarly, crystals having harmonics in the TV IF or RF regions can be used if needed.

Multiple markers can be achieved by feeding the output of an external signal generator into the EXT. MARK. connector. Output of the external generator can be used to give direct marker indication at any frequency within the range of the generator. The MARKER AMP. control will also control the level of any signal fed into the EXT. MARK. connector. Multiple markers are obtained by beating the external generator against either the variable or crystal oscillator at a frequency difference designed to give markers spaced at the required frequency intervals. For example, if 100 kc spaced markers are needed, the external generator should be set to 4.4 mc or 4.6 mc if beat against the crystal oscillator or to a frequency 100 kc above or below the variable oscillator, if this method should be more convenient. When this is done, the sum, the difference and main frequencies will all be present, as well as the harmonics, causing marker pips to be evident all of the way across the trace.

Markers are easily identified, due to the quick disconnect features of the crystal socket and the EXT. MARK. connector. If in doubt as to which marker is the main one, remove the crystal from its socket and disconnect or turn off the external generator if used. The single pip remaining will be that generated by the variable oscillator. Re-establishing the other marker frequencies one at a time will readily identify all other markers. If a fixed marker remains, regardless of whether the marker generator is operating or not, it can be assumed that the marker is generated by the local oscillator of the set under test. A pip of this type can be eliminated if necessary, either by removing the oscillator tube from its socket or disconnecting B+ from the oscillator.

Another feature of the marker generator is that the output of the fixed and variable oscillators can be taken out directly for fixed alignment purposes if required. If a relatively low level signal is required, the output can be taken directly from the RF OUT post with the FINE ATTEN. control turned fully counterclockwise and the MARKER AMP. and ATTENUATOR controls set to the desired level. (The marker signal is attenuated by both controls but not by the FINE ATTEN.)



FM IF AND DETECTOR PATTERNS ARE SIMILAR TO FIGURES E AND F EXCEPT THAT MARKER FREQUENCY WILL USUALLY BE 10.7 MC.

NOTE: IN MANY CASES, THE PATTERNS WILL APPEAR INVERTED ON THE OSCILLOSCOPE SCREEN. PATTERN POLARITY DEPENDS UPON THE TYPE OF DETECTOR EMPLOYED IN THE SET UNDER TEST. INVERTED PATTERNS ARE JUST AS EASY TO INTERPRET AND SHOULD NOT CAUSE DIFFICULTY IN ALIGNMENT

Figure 18

Should higher level output be required, the output cable should be connected to the EXT. MARK. connector and the energy taken directly from the oscillators. When this is done, it must be remembered that the attenuator is ineffective and it may be necessary to attenuate the signal by means of a resistor in series with the "hot" output lead. The value of this resistor will depend upon the amount of attenuation required. When the marker generator is used in this manner, unmodulated signal from the variable or fixed oscillators can be used to align traps, RF and IF tuned amplifiers and discriminators. The 4.5 mc output of the crystal can be used directly for sound IF alignment of intercarrier type TV sets. Traps etc. are adjusted by setting the variable oscillator to the required frequency and adjusting for a null on a VTVM or oscilloscope. The crystal oscillator can be used as a fixed frequency generator for many additional purposes by substituting crystals of the correct frequency for the application. The crystal oscillator was designed to operate with high frequency crystals, operating at frequencies of 1 mc or more and so reliable operation with lower frequency crystals cannot be obtained. When purchasing crystals at a fundamental frequency near 1 mc, make sure that it is a high sensitivity type, for many 1 mc crystals will not function in this type of circuit.

MARKER AMPLITUDE CONTROL

Attenuation of the marker oscillator output is accomplished by use of the MARKER AMP. control. This control should always be set to a point where the markers are easily seen but no higher. Excessive marker amplitude will result in severe distortion of the trace. If distortion is noted when the marker frequency is varied, reduce the control setting until the undesirable condition disappears. It may be difficult to achieve adequate attenuation of marker amplitude when working with extremely high gain circuits. When this occurs, improvement of control can be obtained by increasing the value of the 270 Ω resistor connected between lugs Z1 and Z5 of the attenuator switch. When the markers are not required, they can be turned off by rotating the MARKER AMP. control to MARKER OFF.

SWEEP OSCILLATOR

The sweep oscillator uses the center frequency sweep system, providing excellent frequency and amplitude linearity at all frequencies. Blanking occurs for 180 degrees of the line cycle, which gives an excellent straight reference line to help alignment. To set up the sweep generator, it is only necessary to set the sweep dial to the center frequency of the tuned stage to be aligned and turn up the SWEEP WIDTH control until a satisfactory trace is obtained. If the left hand edge (the low frequency side) of the trace is square instead of coming down to a point with the base reference line, set the sweep dial to a slightly lower frequency until the beginning of the trace comes down to the reference line. See Figure 19. If the right hand edge of the trace is squared off, increase the frequency setting of the OSCILLATOR dial. When both ends are clipped increase the SWEEP WIDTH control setting. Center the trace by adjusting the HOR. PHASE and OSCILLATOR controls as necessary.

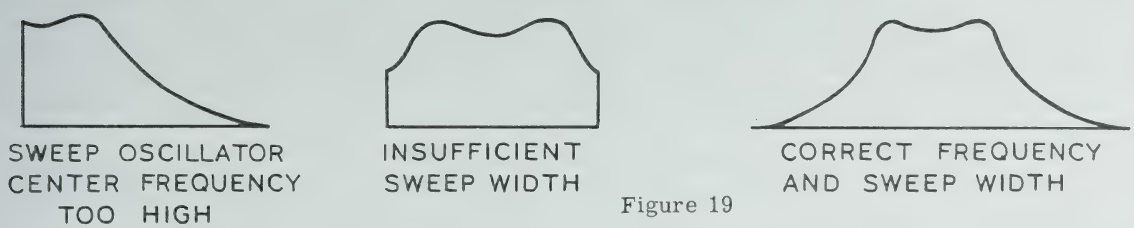


Figure 19

High fundamental output from the sweep oscillator makes it possible to align single or multiple stages of a receiver as required. The output is more than sufficient to give a very readable trace on a scope connected to the video detector when the generator is connected to the grid of the last video IF stage. Careful design of the attenuator circuit gives adequate control of this high output level, allowing easy operation of the instrument into multiple stage high gain amplifiers as well as single stages of the same RF or IF strip. An additional advantage of the high output is that the fourth and fifth harmonics of the high band (band D) are strong enough to give readable traces on UHF channels, if the oscilloscope is connected to the video detector. To identify these frequencies, however, harmonics of a VHF signal generator or output of a UHF generator should be used as markers.

Another feature of the sweep generator is the extremely wide band sweep width available. For normal applications the SWEEP WIDTH control will not be advanced very far. If desired, however the SWEEP WIDTH can be advanced to a point where all traps as well as the IF and RF bandpass waveforms can be seen. As the operator becomes more familiar with the unusual characteristics of the instrument, additional uses will be found for this large reserve of sweep width, for this feature can frequently save a considerable amount of time in trap alignment, etc.

BAND CONTROL

The BAND control switch is used to select the range of frequencies covered by the sweep oscillator. Proper bands can be identified by noting the corresponding letters below the sweep oscillator dial. Band A is the low band covering a range of 3.6 mc to 10 mc; band B, 10 mc to 26 mc; band C, 30 mc to 80 mc and band D, 80 mc to 220 mc. The figures on the OSCILLATOR dial refer to the frequency at the center of the sweep. A point to remember is that the upper frequency of the sweep oscillator is not limited by the highest indicated frequency on the OSCILLATOR dial for the unit is capable of sweeping across bands. Another point worth considering is that the maximum available sweep width on each band is generally achieved with the sweep frequency indicator set near the high frequency side of any given band. In other words, more sweep width will be available at the high end of band B than at the same frequency at the low end of band C, etc.

HORIZONTAL PHASE

Compensation for phase shift in the receiver under test is accomplished by proper use of the HOR. PHASE control. Before setting the OSCILLATOR and SWEEP WIDTH controls to produce a bandpass waveform, the phasing control should be set to approximately 12 o'clock. Once the desired waveform is obtained, the phase control should be adjusted until the trace is centered or shows no foldover at the right or left hand edges. Adjustment is completed by careful touch up of the OSCILLATOR, SWEEP WIDTH and HOR. PHASE controls. Figure 20 clearly illustrates proper adjustment of the phasing control.

Frequency linearity is dependent on phase control settings to a certain extent. If non-linearity becomes evident, reset the phase control and center the trace, using the OSCILLATOR dial.

Figure 20

SWEEP WIDTH

The SWEEP WIDTH control is used to control the amount of sweep deviation of the sweep oscillator. The OSCILLATOR dial is set to the center frequency of the IF or RF stage to be aligned as described previously and the SWEEP WIDTH control advanced until the trace is completed. This control should be set just high enough to give complete coverage of the bandpass waveform when IF or RF adjustments are to be made. If trap settings are to be observed also, the setting may be increased as required.

FINE ATTENUATOR AND ATTENUATOR

Output of the sweep generator is controlled by the FINE ATTEN. and ATTENUATOR controls. Alignment should usually be started with the ATTENUATOR in the X1 position and the FINE ATTEN. at approximately 5. As soon as a response is obtained, the settings should be increased or decreased as required. Good alignment practice requires that the output be kept as low as possible, consistent with good indication on the oscilloscope screen. Too much output will result in serious distortion of the trace and misalignment. To make sure that the response is not distorted, back the FINE ATTEN. control off, observing the waveform. If a point is found where the waveshape changes, the IF or RF strip of the receiver was overloaded. Final attenuator settings should be made at a point below that at which distortion occurred. If it becomes necessary to set the FINE ATTEN. control to a point near 1 on the dial, the ATTENUATOR switch should be backed off a position and the other control reset. The FINE ATTEN. control affects the sweep oscillator only, while the ATTENUATOR switch attenuates the sweep and marker output at the same time, helping to prevent marker overloading.

GENERAL ALIGNMENT PROCEDURES USING THE HEATHKIT SWEEP GENERATOR

Most television receivers will fall into one of four general patterns of alignment, which will be described later. However, each different set will have one or more special procedures involved in relation to special circuits in the set, so it is very desirable that the manufacturer's instructions be available and used. In addition to the time saved, better results will undoubtedly be obtained.

For all alignment except RF, it is necessary to render the local oscillator of the TV receiver inoperative. This is done either by removing the oscillator tube or temporarily removing the B+ lead to its plate circuits. Also, the AGC circuit should be made ineffective by removing the AGC tube, if necessary, and grounding the AGC bus or applying a fixed DC potential from a battery or potentiometer, as required by the manufacturer. For safety, the high voltage to the picture tube should be eliminated by removing the horizontal oscillator tube or the horizontal multivibrator tube, depending on the type of circuits involved.

Alignment of any television receiver should not be attempted unless there is evidence of misalignment. By connecting an oscilloscope and the Heathkit Television Alignment Generator to the receiver as outlined below and checking the gain of each stage before any adjustments are made, an excellent idea of stage gain is obtained and any stage not showing gain can be checked. A check of the tubes and other circuit elements is recommended before changing tuned circuits.

Generally, alignment is started with the trap circuits. The sound traps which keep the audio from modulating the picture and the traps to prevent adjacent channels from interfering are almost always aligned before the balance of the receiver. The 4.5 mc trap in most intercarrier type sets should be aligned after the sound and video IF strips have been adjusted in most cases. Sound IF sections are aligned with conventional FM procedure. The TV tuner oscillator and RF sections are aligned only if defective indication is observed showing that misalignment has taken place.

SOUND AND ADJACENT CHANNEL TRAP ALIGNMENT

A DC vacuum tube voltmeter is generally used as the indicator for trap adjustment. The indicator is connected across the second detector load resistance. CW (unmodulated) signal from the marker generator is coupled into the grid of an IF stage ahead of the trap circuit through a .001 μfd or larger condenser. The marker generator is tuned to the trap circuit frequency and its output increased until an indication is observed. Adjust the trap for minimum indication. Locate the other traps and resetting the generator to the proper frequency, adjust each for minimum indication. Energy from the marker oscillator can be taken from the RF OUT connector by setting the FINE ATTEN. and ATTENUATOR to 0 and X1 respectively and placing the BAND switch at position D, so that the sweep oscillator will not cause interference. Should the output be too low when signal is taken from this point, connect the output cable to the EXT. MARK connector instead and attenuator the signal as necessary by installing a suitable value of resistance in series with the "hot" lead. In cases where the manufacturer specifies a modulated signal for trap alignment, refer to the manual section headed SPECIAL PROCEDURES.

INTERMEDIATE FREQUENCY (IF) ALIGNMENT
STAGGER TUNED TYPE

To align stagger tuned type IF stages, the output of the generator is either fed to the grid of the mixer tube through a capacitor or to the grid of each individual stage as it is aligned, in sequence, beginning at the stage before the video detector. Manufacturer's instructions regarding this should be followed in all cases. The oscilloscope is connected across the load resistance of the picture detector. Loading of this stage of the receiver is prevented by use of the special oscilloscope lead furnished with the kit, which has an isolating resistor built in. Connect the horizontal input of the scope to the HOR. and GND. posts of the sweep generator. Render the TV receiver oscillator tube inoperative by using one of the previously described methods. Set the OSCILLATOR dial to the frequency of the IF strip and advance the SWEEP WIDTH control until a large, easily seen trace appears. If the horizontal line at each end of the trace is too long, the sweep width should be reduced and the sweep oscillator frequency adjusted slightly if necessary to properly center the trace. If the trace does not return to the horizontal line, the sweep width should be increased. Regardless of the amount of sweep used, the width of the band pass trace will be limited by the band width of the IF amplifiers under test and a more accurate trace will be obtained by using all of the trace for the amplified portion.

The MARKER AMP. control is advanced and the MARKER control adjusted to the frequency of the first IF stage as outlined in the manufacturer's instructions and this stage adjusted for maximum indication. If recommended, the primary of the IF transformer preceding the stage under alignment should be shorted. The marker pip is then moved to the frequency of the next stage and this stage adjusted. Be sure to reduce the output of the generator as alignment proceeds. Use maximum gain of the oscilloscope vertical amplifier during entire alignment always reducing output of the generator rather than that of the scope. Each IF stage is aligned in the above manner. The overall response is then compared with the recommended curve in the manufacturer's instructions. The locations of the sound and picture sections can be checked with the dual markers and compared with proper positions. Slight readjustment of individual stages may be necessary to properly match manufacturer's recommended trace. The overall response check is usually made by feeding the output of the generator to the mixer grid through a capacitor of suitable size.

In some cases, the IF stages will be prealigned using fixed frequency procedure with a VTVM used as an output indicator at the video detector stage. When this type of alignment is called for, the marker oscillator can be used as a signal generator by turning the FINE ATTEN. to its maximum counterclockwise position and the ATTENUATOR and MARKER AMP. controls to a point that will give adequate output. If it should be impossible to obtain sufficient output in this manner, the signal can be taken directly from the EXT. MARK. connector and attenuation accomplished by use of a suitable value of resistance in series with the "hot" output lead.

OVERCOUPLED IF TYPE

Connections are made with the scope as outlined under stagger tuned types. The output of the alignment generator is fed into the grid of the final IF stage (nearest picture detector) through a coupling capacitor (.001 μfd). Proceed to align the last IF transformer in the manner outlined in the manufacturer's instructions. Manufacturers usually supply a pattern to be obtained for each stage and these should be followed. It is sometimes necessary to short out the primary of the IF transformer preceding the stage under alignment and this should be done when recommended. Alignment proceeds stage by stage from the stage nearest the picture detector to the mixer tube. After alignment of the final stage, the trace should appear similar to the typical TV IF response curve shown in the instructions. The markers are again used to locate sound and picture carriers to check shape and width of the trace.

Fixed frequency pre-alignment procedures may be used for this type of IF system. When this is the case, observe the instructions under STAGGER TUNED TYPES.

SOUND IF ALIGNMENT

Discriminator, ratio detector and beam gated circuits are commonly encountered as detectors in TV sound IF systems. Except for the gated beam detector, alignment procedures are much the same, the only difference being the point to which the oscilloscope is connected. In almost all cases, the output of the sweep generator will be connected to the grid of the first sound IF amplifier through a suitable capacitor.

To observe the bandpass waveform in a circuit employing a discriminator, the scope should be connected to the grid return of the last limiter tube and the output of the generator increased to give a satisfactory trace. The marker is set to the center frequency of the sound IF strip and adjustments are made keeping the waveform symmetrical on each side of the marker. When this adjustment is completed, the scope is connected at the volume control or at the opposite side of the isolating resistor running to the control and the discriminator transformer adjusted for maximum amplitude and straightness of the slanted detecting curve. Adjustment is complete when the marker is in the center of the curve. (NOTE: The crystal oscillator will furnish the marker for 4.5 mc intercarrier type sound systems.)

When a ratio detector is employed, the scope should be connected to the plate of the detector or diode which is in turn connected to the negative terminal of an electrolytic stabilizing condenser. This condenser should be disconnected to make IF transformer adjustments. After the IF stages are properly adjusted, the condenser is reconnected and the oscilloscope vertical test lead connected to the "hot" terminal of the volume control. Final adjustments are made as in the preceding paragraph.

Adjustments of beam gated stages are generally made on actual signal from a television broadcasting station and alignment methods described by the manufacturer should be used. Where modulated fixed frequency signal sources are required, refer to the manual section under SPECIAL PROCEDURES.

OSCILLATOR AND RF ALIGNMENT

Alignment of the tuner section of a TV receiver should not be attempted unless the performance of the set indicates the necessity of doing so. When necessary, alignment is usually started by adjusting the oscillator frequency, after the oscillator is restored to operation. To accomplish this, the alignment generator is connected to the antenna terminals of the set through suitable impedance matching resistors (usually 120 Ω) in series with the ground and hot lead of the output cable. The scope is connected to the video detector as before. Alignment is begun starting at the highest frequency (channel 13) and finishing at the lowest frequency (channel 2) unless otherwise specified.

Oscillator tuning is adjusted to place the sound and video markers at the manufacturer's specified points on the response curve. Where marker frequencies higher than those marked on the MARKER dial are called for, the fourth harmonic of the variable oscillator can be used. The specified marker frequency is divided by four and the marker dial set to the resulting frequency. 4.5 mc spacing of markers for identification of the other carrier will be generated by the crystal oscillator.

When fixed frequency alignment procedures are recommended, harmonic or fundamental output of the variable marker oscillator can be used, taken from the appropriate output connector. A vacuum tube voltmeter will be used as an indicator when this method of alignment is undertaken. The VTVM is usually connected to the load for the sound detector and the oscillator adjustment made for zero reading (a null). Other connection points for the VTVM may be recommended and these should be used as specified by the manufacturer.

After oscillator alignment is completed, RF and mixer alignment is done. The sweep generator remains connected to the antenna terminals through matching resistors and the oscilloscope is usually connected to the grid return of the mixer tube at a point specially provided for this purpose. Alignment is again started at the highest frequency channel and the response waveform adjusted to conform to the recommended shape. (NOTE: The output level at the signal takeoff point in the tuner is usually quite low and most oscilloscopes have insufficient vertical gain to give an easily readable pattern. When this condition is encountered, a single stage pentode preamplifier such as a microphone pre-amp should be used ahead of the scope to increase the gain to a satisfactory level. Sometimes a demodulator probe connected at the recommended point will give better results without a preamplifier. This situation will not develop when alignment instructions specify that the scope be connected to the video detector.

INTERCARRIER TYPE SETS

Intercarrier alignment procedures are much the same as those previously specified. Usually the video IF strip is aligned using fixed frequency procedure with a VTVM as a detector. The VTVM is usually connected to the video detector load and IF adjustments made for maximum indication. Again, direct output from the variable or fixed marker oscillator can be used. If sweep techniques are called for, the previously described methods can be used.

After alignment is completed using fixed frequency methods, the overall response is checked with the sweep generator and scope. This is accomplished with the generator connected to the mixer stage and the scope to the video detector. If necessary, the IF adjustment screws are touched up to get the waveform to conform to the recommended pattern.

Sound IF alignment is accomplished as before, except that the 4.5 mc crystal is used exclusively as the signal source or marker, depending upon the alignment method employed. After the sound strip is correctly aligned, the 4.5 mc trap (if any) is adjusted using the 4.5 mc output of the marker and a VTVM with an RF probe at the cathode or grid of the picture tube. In some cases, the DC probe of the VTVM will be connected instead to a point in the sound detector circuit. In all cases, the manufacturer's instructions should be followed.

Alignment procedures for the tuner of intercarrier type sets will follow the same general course outlined under OSCILLATOR AND RF ALIGNMENT, mentioned previously.

FM RECEIVER ALIGNMENT

The alignment of FM receivers is similar to the outline under SOUND IF ALIGNMENT of television receivers. The normal FM IF frequency is 10.7 mc and as nearly every signal generator covers this frequency, markers can easily be obtained from external generators and fed into the EXT. MARK. connector of the alignment generator. If extremely accurate alignment is required a 10.7 mc or 5.35 mc crystal can be plugged into the XTAL socket.

Extra bandwidth identification markers may be achieved by use of an external signal generator tuned to a frequency 100 kc above or below the frequency of the crystal oscillator. In some cases a satisfactory 10.7 mc marker can be obtained by setting the marker oscillator dial to the second harmonic of the receiver IF frequency, or 21.4 mc. This does not always provide a satisfactory marker, but it may work out well with a large percentage of FM sets encountered.

SPECIAL PROCEDURES

In some cases, a modulated RF signal is required for adjustment of traps, detectors, etc. If the operator is thoroughly familiar with the type of circuits involved, other methods of alignment can sometimes be used, employing the output of the marker generator. When methods other than those recommended are not feasible, certain steps should be taken to insure alignment accuracy consistent with that of the alignment generator. Observance of the following instructions will help to improve the performance of the receiver after alignment is completed.

When a modulated signal for trap alignment is called for, an unmodulated signal can sometimes be used in conjunction with a DC VTVM connected to the video or audio detector, depending on the location of the trap in the circuit. The usual procedure is to connect an AC meter or an oscilloscope to the grid or cathode of the picture tube when a modulated signal is used. Regardless of which method is employed, the trap will be tuned for minimum indication. If it is essential that a modulated source be used, a separate signal generator must be employed. Before using the external generator to make adjustments, it should be zero beat against the crystal or variable marker generator, depending upon the frequencies involved. This can be accomplished by feeding the output of both generators to the RF probe of a signal tracer or to the input of a receiver tuned to the frequency in question. This method of instrument calibration should always be used to keep alignment consistent with the original aligning instrument. While errors in any given instrument may be small, they may be in opposite directions and the resultant error may be sufficient to cause the set under alignment to perform at less than optimum level.

Occasionally a modulated signal is required to adjust the detector of the sound strip in TV or FM sets. The procedure outlined under SOUND IF ALIGNMENT can sometimes be substituted with very good results. However, if any doubt as to the efficiency of this method exists, the recommended procedure should be observed. Again the external generator should be calibrated against the marker generator to insure best performance.

Too many different procedures exist for aligning of beam gated detectors to outline all of them within this manual. Generally, these detectors are aligned on station with attenuation in the antenna circuit to keep the signal level below the limiting level of the detector. The IF transformers are adjusted for maximum indication, using a scope of AC meter across the volume control and keeping the input attenuated below the limiting level of the detector. After these adjustments are made, the input is increased beyond the limiting point and the AM rejection control in the cathode circuit and the quadrature coil adjusted for minimum intercarrier buzz. When a modulated signal source is used to align this type of circuit, the external generator should be calibrated against the marker generator.

ACCESSORY INSTRUMENTS

A stable, high sensitivity, wide band oscilloscope is a must if satisfactory alignment is to be accomplished with a minimum of nervous strain. Although wide band response is not required for sweep alignment purposes, it is desirable for observance of synchronizing pulses, etc. encountered when doing routine service work on television receivers. The Heathkit OL-1, OM-1 and O-10 oscilloscopes meet these requirements and incorporate other refinements very useful in general service work. High intensity levels along with excellent focusing characteristics make it easy to operate these scopes even in brilliantly illuminated rooms.

Two probe kits are available which add to the usefulness of the oscilloscope. One is the #342 Low Capacity Probe which allows accurate measurement of sync waveforms etc. in high impedance circuits. Normally, distortion occurs when a scope is connected to a high impedance point where complex waveforms are present, due to capacitive loading by the scope input. The #342 probe effectively cancels this capacity, thus preventing distortion.

Signal tracing and waveform checks in the RF sections of receivers can be made using the #337C Demodulator Probe. This probe is also useful for making stage gain measurements in low impedance RF circuits.

Another instrument that is absolutely necessary for alignment purposes is a high impedance vacuum tube voltmeter. The Heathkit V-7 VTVM has an input impedance of 11 megohms on all DC ranges. This is sufficiently high to make loading effects negligible and all readings will be true indications of potential existing in the circuit under investigation. An additional advantage of this type of VTVM is that a variety of probes can be used, greatly extending the usefulness of the instrument. A high voltage probe and an RF probe are available as accessories. This instrument features many ranges of peak-to-peak and RMS AC and OHMS as well, making it extremely useful for all general service work.

Although not essential, a grid dip meter such as the Heathkit GD-1B is very useful for television and general service work. Every serviceman is familiar with the occasional set that comes into the shop with all of the alignment screws tightened down. It is extremely difficult to put sets in this condition back into alignment, for it is almost impossible to jam an alignment signal through the set. A grid dip meter can be used to make surprisingly close rough adjustments of the tuned circuits and traps with the set "cold." Finishing touch-up of alignment is then easy. Another use of the grid dip meter employs the instrument as a marker generator. The grid dipper operates over a very wide range of frequencies, all on fundamentals, making it especially useful for tuner alignment work. To be used as a marker, the grid dipper is merely placed near the set under alignment, no direct connections are needed. Many additional uses of this instrument have been listed in various magazines and even more may become apparent as the operator becomes more familiar with the characteristics of the unit.

Finishing touches on the completely serviced television set can be made using the Heathkit BG-1 Bar Generator. This instrument generates horizontal and vertical bars which are evenly spaced making horizontal and vertical linearity adjustments easy. A few moments spent making these simple adjustments can result in a large amount of customer good will.

IN CASE OF DIFFICULTY

1. Recheck the wiring. Trace each lead in colored pencil on the pictorial and schematic as it is followed in the instrument. Most cases of difficulty result from wrong connections. Often having a friend check the wiring will reveal a mistake consistently overlooked.
2. If possible, compare tube socket voltages with those shown on Page 37. The readings should be within 20% of those tabulated if a VTVM is used. Other type meters may give lower readings due to loading effects. If the voltage fails to compare with the value shown, check further into the circuit involved by checking the various components (resistors, condensers, tubes, etc.)

Carefully recheck the color codes on resistors and transformer leads. If there is a question concerning the color of a transformer lead, scraping the insulation lightly with a knife may help to identify the color quickly.

Some common troubles are listed below along with trouble-shooting procedures which may be helpful in locating the source of difficulty.

INSTRUMENT COMPLETELY INOPERATIVE: If the instrument fails to operate, check the tubes to see if the filaments are lit. If there is no evidence of heating, measure across the end of the AC line at the terminal strip next to the grommet on the back of the chassis. Lack of AC energy at this point indicates either an open line cord or imperfect connection at the outlet. The AC cord can be checked quickly with an ohmmeter. When voltage is obtained at this point on the terminal strip, the voltmeter should be moved to the strip at the opposite end of the line chokes.

VOLTAGE CHART

SOCKET TUBE TYPE	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9
12AX7	70	-8	0	6.3 VAC	6.3 VAC	-23	-23	75 VAC	0
12AT7	135	-10 to -30	1.5	6.3 VAC	6.3 VAC	210	-10 to -25	1.5	0
6CL6	0	-2.4	150	0	6.3 VAC	100	0	NC	-2.4
6X4	210 VAC	*	6.3 VAC	0	NC	210 VAC	250		
6BQ7A	150	NS	1.7	6.3 VAC	0	96	-9	0	0

NS - not significant. NC - no connection.
Line voltage: 115 volts AC
* - voltage from 6X4 pin 2 to terminal strip T1, 115 volts AC.
Unless otherwise indicated, all voltages positive and measured to chassis.
Voltages taken with a Heathkit 11 megohm VTVM.
Bias voltage across inductor primary terminals: 6 volts on bands A, B and C, 15 volts on band D.
Readings taken with BAND switch at C, MARKER and OSCILLATOR dials full clockwise.
MARKER AMP. and HOR. PHASE about 1/2 open and all other controls fully counterclockwise.

No voltage at this point indicates an open choke. Finally, check with the meter connected across the black and red-black leads of the power transformer. No voltage at this point indicates a defective switch on the back of the phase control or a wiring error.

Should voltage be present at all points in the 110 volt AC circuit, a short in the filament or rectifier plate or cathode circuits can be suspected. Careful visual inspection will usually reveal the source of trouble. If not, all tubes should be removed and the power transformer disconnected from the circuit. Ohmmeter checks for wiring shorts can then be made and power transformer checked for open windings.

NO SWEEP OSCILLATOR OUTPUT: Lack of RF output can be traced to either failure of the oscillator to function or a defect in the attenuator and output network. Check components and connections in the attenuator network to make sure that everything is wired properly and no shorts exist. Once sure that everything is all right at this point, pins 1 and 6 of the 6BQ7A sweep oscillator should be checked to see if B+ is present. Special attention should be given to the four stator lugs on the variable condenser. B+ should be present at all four terminals. If not, carefully check the stator lug connections for a break. If a break is present, it can be repaired quickly by resoldering the connections.

Failure of the sweep oscillator to function due to voltages far out of line with those shown on the voltage chart might be caused by a defect somewhere in the power supply or by improper connection of the wires running from the main chassis to the sweep sub-chassis. Once sure that the interconnecting wires are connected properly, check under POWER SUPPLY MALFUNCTION.

Tubes can always be suspected of causing trouble, especially at higher frequencies. It might be worthwhile to substitute tubes to see if performance can be improved. While a certain tube might not operate will in one circuit, it may be perfectly good in another and so exchanging identical types is often advantageous.

NO MARKER OSCILLATOR OUTPUT: The same procedure as outlined above should be observed. Again, special attention should be given to the four stator lugs on the tuning condenser. Lack of high voltage on the plates (pins 1 and 6) of the 12AT7 will indicate either an open RF choke or a defective switch on the MARKER AMP. control. If the choke is open, repairs can usually be made by soldering the choke leads carefully close to the body of the choke. Checks should also be made for short circuits in the wiring, the tube and the tuning condenser.

POWER SUPPLY MALFUNCTION: To locate trouble in the power supply, voltage checks should be made in a definite sequence. First, pins 1 and 6 of the 6X4 socket should be checked for AC voltage. Next, check all filaments to make sure that they are lit. If not, check for a short, open circuit or misconnection at one of the sockets. If everything is all right at these points, the potential at pin 7 of the 6X4 should be checked. If no B+ exists, look for a short in the B+ line and in the filter condenser. Also, check the 6X4 for open circuits and low emission. When sure that everything is correct at these points, check voltage at pin 1 of the 12AX7 and pins 3 and 6 of the 6CL6. Discrepancies at these points should be straightened out before going further. Possible sources of trouble are the .25 μfd condenser connecting between pin 1 of the 12AX7 and pin 9 of the 6CL6, the .06 μfd condenser between ground and the 220 Ω resistor to pin 6 of the 6CL6, leakage to ground in the 30 h plate choke, short circuits at terminal strips K, H and BP, and defective parts or wiring around the front wafer of switch BM. Short circuits are easily located by disconnecting wires one at a time from the point where the short is found. A follow up of the wire which remains shorted will reveal the fault.

The final power supply check point is at pin 6 of the 6CL6. If no voltage or low voltage is present at this point regardless of whether or not the tube is in its socket, the sweep oscillator chassis should be checked for short circuits and wiring errors.

NO HORIZONTAL OUTPUT FOR SCOPE: If it should be impossible to obtain a horizontal line on the scope, the lead running between the two instruments should be checked for open or short circuits. Also, the 1 megohm, the two 100 KΩ resistors and the 100 KΩ potentiometer should be checked as well as the .01 μfd and the .05 μfd condenser used in the phasing circuit.

If sweep can be obtained but the phasing control is ineffective, there is a possibility that the wires from the 6X4 socket and terminal strip K have been accidentally exchanged. Reversal of the wires will correct this condition. If the wiring is all right, make sure that the 1 megohm resistor is connected to the proper point on the phase control and that the .01 μfd high voltage condenser is not shorted.

NO FREQUENCY SWEEP: Lack of sweep or sweep width will be caused by some defect in the 110 volt circuit leading to the controllable inductor. The 10 KΩ sweep width control should be checked for continuity as well as the 6800 Ω resistor connected to it. A shorted .25 μfd condenser across the primary of the inductor or an open 12 μfd between the control and the inductor will cause lack of sweep. Voltage at the small selenium rectifier should be checked since this provides bias for the Increductor unit. Connections to the front wafer of the band switch should be inspected and the switch itself checked against the schematic to be sure that everything is correct.

REVERSED SWEEP: Should the markers move from right to left on the trace when the marker frequency is increased, the sweep oscillator is unblanking on the wrong phase of the AC line. This condition can be corrected, if desired, by reversing the black and red-black power transformer primary wire connections.

POOR FREQUENCY LINEARITY AND CALIBRATION: Poor linearity and calibration will most likely be caused by improper biasing of the controllable inductor. The steps outlined under NO FREQUENCY SWEEP should be observed and the 18 KΩ and 10 KΩ resistors which make up the load for the biasing circuit checked out. Very high or low line voltage will have some effect on linearity and frequency, but the errors will not be serious. A substantial deviation from recommended value of these resistances could cause poor operation.

POOR AMPLITUDE LINEARITY: A non-linear trace indicates improper biasing on either the 12AX7 AGC amplifier or the 6CL6 regulator. The 220 KΩ, 22 megohm and 5.6 megohm resistors on the front deck of the band switch should be checked for value and connection. These resistors control the bias on the 12AX7 regulator amplifier. If the trouble shows up only on the low end of band D, the 1 megohm resistor between pin 1 of the 12AX7 and pin 2 of the 6CL6 should be checked. If the value is approximately correct, it may be necessary to reduce it slightly until the regulation is perfect. Decreasing the value of this resistor will also decrease the output of the sweep generator, however, so care should be exercised.

Poor regulation on the lower frequency bands or all bands will most likely be due to some fault around the resistors or switch previously mentioned.

Amplitude or output variations can be expected as sweep frequency settings or band settings are changed. This is not important, since these adjustments will not be made during any alignment procedure. The important thing is that the output be flat over any given sweep width with the center frequency set at a common reference.

MARKER DISTORTION: In some cases, distortion of the trace will occur when the marker oscillator is turned on. This condition will most usually be encountered when overall alignment techniques are employed in high gain IF or RF circuits. This condition can usually be alleviated by simply increasing the value of the 270 Ω resistor which connects between step attenuator switch Z1 and Z5. The value should be increased until the marker action is satisfactory. Where insufficient marker amplitude is evident, the value can be decreased to obtain the desired results.

REPLACEMENTS

Material supplied with Heathkits has been carefully selected to meet design requirements and ordinarily will fulfill its function without difficulty. Occasionally improper instrument operation can be traced to a faulty tube or component. Should inspection reveal the necessity for replacement, write to the Heath Company and supply all of the following information:

A. Thoroughly identify the part in question by using the part number and description found in the manual parts list.
B. Identify the type and model number of kit in which it is used.
C. Mention the order number and date of purchase.
D. Describe the nature of defect or reason for requesting replacement.

The Heath Company will promptly supply the necessary replacement. Please do not return the original component until specifically requested to do so. Do not dismantle the component in question as this will void the guarantee. If tubes are to be returned, pack them carefully to prevent breakage in shipment as broken tubes are not eligible for replacement. This replacement policy does not cover the free replacement of parts that may have been broken or damaged through carelessness on the part of the kit builder.

SERVICE

In event continued operational difficulties of the completed instrument are experienced, the facilities of the Heath Company Service Department are at your disposal. Your instrument may be returned for inspection and repair for a service charge of $5.00 plus the cost of any additional material that may be required. THIS SERVICE POLICY APPLIES ONLY TO COMPLETED INSTRUMENTS CONSTRUCTED IN ACCORDANCE WITH THE INSTRUCTIONS AS STATED IN THE MANUAL. Instruments that are not entirely completed or instruments that are modified in design will not be accepted for repair. Instruments showing evidence of acid core solder or paste fluxes will be returned not repaired.

The Heath Company is willing to offer its full cooperation to assist you in obtaining the specified performance level in your instrument. Factory repair service is available for a period of one year from the date of purchase or you may contact the Engineering Consultation Department by mail. For information regarding the possible modification of existing kits, the volumes listed in the Bibliography section are recommended. They can be obtained at or through your local library, as well as at any electronic outlet store. Although the Heath Company sincerely welcomes all comments and suggestions, it would be impossible to design, test, evaluate and assume responsibility for proposed circuit changes for specific purposes. Therefore, such modifications must be made at the discretion of the kit builder according to information which will be much more readily available from some local source.

SHIPPING INSTRUCTIONS

Before returning a unit for service, be sure that all parts are securely mounted. Attach a tag to the instrument giving name, address and trouble experienced. Pack in a rugged container, preferably wood, using at least three inches of shredded newspaper or excelsior on all sides. DO NOT SHIP IN THE ORIGINAL KIT CARTON AS THIS CARTON IS NOT CONSIDERED ADEQUATE FOR SAFE SHIPMENT OF THE COMPLETED INSTRUMENT. Ship by prepaid express if possible. Return shipment will be made by express collect. Note that a carrier cannot be held liable for damage in transit if packing, in HIS OPINION, is insufficient.

SPECIFICATIONS

All prices are subject to change without notice. The Heath Company reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to incorporate new features in instruments previously sold.

WARRANTY

The Heath Company limits its warranty of parts supplied with any kit to a period of three (3) months from the date of purchase. Replacement will be made only when said part is returned postpaid, with prior permission and in the judgment of the Heath Company was defective at the time of sale. This warranty does not extend to any Heathkits which have been subjected to misuse, neglect, accident and improper installation or applications. Material supplied with a kit shall not be considered as defective, even though not in exact accordance with specifications, if it substantially fulfills performance requirements. This warranty is not transferable and applies only to the original purchaser. This warranty is in lieu of all other warranties and the Heath Company neither assumes nor authorizes any other person to assume for them any other liability in connection with the sale of Heathkits.

The assembler is urged to follow the instructions exactly as provided. The Heath Company assumes no responsibility or liability for any damages or injuries sustained in the assembly of the device or in the operation of the completed instrument.

HEATH COMPANY
Benton Harbor, Michigan

BIBLIOGRAPHY

Alignment data can usually be obtained from the manufacturer of the set in question. Some other excellent sources of the same information are listed below:

Photofact Publications; Howard W. Sams and Company, Inc.
Perpetual Trouble-Shooters Manuals; Rider, John F.

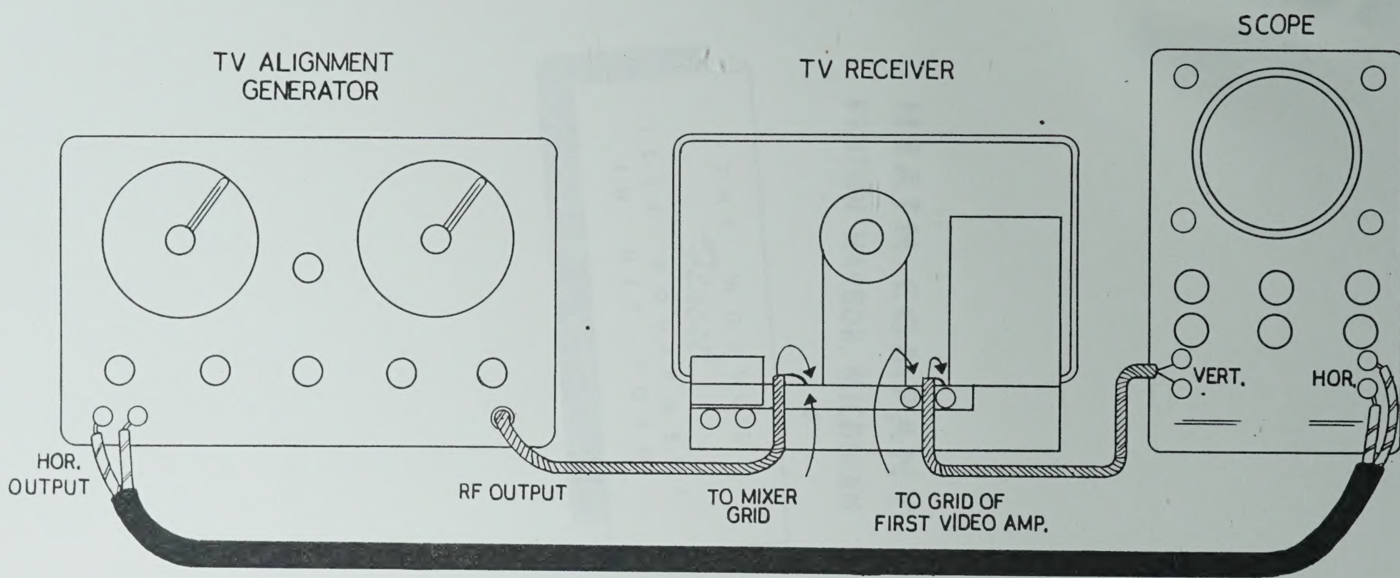
Many fine books and pamphlets are currently available describing approved techniques using modern instruments for all types of general service and developmental work. Information concerning this literature can usually be obtained from the catalogs put out by large electronic wholesale concerns. A few booklets written especially for television servicing and alignment are also presently obtainable. Some of these are listed below:

Kiver, Milton S.; How to Understand and Use TV Test Instruments
Liebscher, Art.; TV Sweep Alignment Techniques

PART No.	PARTS Per Kit	DESCRIPTION
Resistors		
1-1	3	47 Ω 1/2 watt
1-2	1	68 Ω 1/2 watt
1-7	2	680 Ω 1/2 watt
1-16	2	4700 Ω 1/2 watt
1-19	1	6800 Ω 1/2 watt
1-22	2	22 KΩ 1/2 watt
1-24	1	33 KΩ 1/2 watt
1-26	5	100 KΩ 1/2 watt
1-27	1	150 KΩ 1/2 watt
1-29	1	220 KΩ 1/2 watt
1-35	3	1 megohm 1/2 watt
1-41	1	10 Ω 1/2 watt
1-42	1	270 Ω 1/2 watt
1-44	1	2200 Ω 1/2 watt
1-45	1	220 Ω 1/2 watt
1-47	1	56 KΩ 1/2 watt
1-66	1	150 Ω 1/2 watt
1-70	1	22 megohm 1/2 watt
1-86	1	5.6 megohm 1/2 watt
1-1A	1	470 Ω 1 watt
1-25A	1	6.8 KΩ 1 watt
1-27A	2	33 KΩ 1 watt
1-44A	1	18 KΩ 1 watt
1-3B	1	10 KΩ 2 watt
1-17B	1	6800 Ω 2 watt
3-6J	1	2500 Ω 10 watt
1-9A	1	10 KΩ 1 watt
Condensers		
21-9	3	100 $\mu\mu$f
21-11	1	150 $\mu\mu$f
21-14	10	1000 $\mu\mu$f
21-16	1	.01 μfd disc
21-27	1	5000 $\mu\mu$f
21-32	1	47 $\mu\mu$f
23-4	1	.01 μfd 1000 volt
23-55	1	.06 μfd 400 volt
23-59	1	.05 μfd 200 volt
23-63	2	.25 μfd 400 volt
25-5	1	16 μfd 150 volt
25-20	1	40 μfd 150 volt
25-30	1	20-20 μfd 350 volt
26-10	2	Tuning condenser
Tubes-Lamp-Diode-Crystal		
57-1	1	Selenium rectifier
404-1	1	4.5 mc crystal
411-24	1	12AT7 tube
411-26	1	12AX7 tube
411-63	1	6CL6 tube
411-64	1	6X4 tube
411-71	1	6BQ7A tube
412-1	1	#47 pilot lamp

PART No.	PARTS Per Kit	DESCRIPTION
Sockets-Terminal Strips-Insulators		
70-2	3	Acetate sleeve, black
70-3	3	Acetate sleeve, red
75-11	2	Insulated chassis board
75-15	1	Terminal half-shell, drilled
75-16	1	Terminal half-shell, plain
100-M16B	2	Binding post cap, black
100-M16R	2	Binding post cap, red
431-1	1	1-lug terminal strip
431-2	3	2-lug terminal strip
431-3	1	3-lug terminal strip
431-10	3	3-lug terminal strip
431-12	1	4-lug terminal strip
431-14	2	2-lug terminal strip
431-15	2	1-lug terminal strip
434-15	1	7-pin tube socket
434-16	4	9-pin tube socket
434-22	1	Pilot lamp socket
434-38	1	Crystal socket
453-10	1	Insulated extension shaft
453-11	1	Insulated extension shaft
456-1	2	Flexible shaft coupling
Hardware		
250-2	10	3-48 x 1/4 screw
250-7	4	6-32 x 3/16 screw
250-8	2	#6 x 3/8 sheet metal screw
250-9	20	6-32 x 3/8 screw
250-18	2	8-32 x 3/8 screw
250-19	2	10-24 x 3/8 screw
250-25	6	4-40 x 1/8 screw
250-34	1	4-40 x 1/2 screw
250-40	7	6-32 x 1 1/2 screw
250-43	8	8-32 x 1/4 set screw
250-48	1	6-32 x 1/2 screw
252-1	10	3-48 x 7/32 nut
252-3	26	6-32 x 1/4 nut
252-4	4	8-32 x 3/8 nut
252-7	8	3/8-32 x 1/8 control nut
252-12	1	Pilot light nut
252-15	1	4-40 x 3/16 nut
253-1	2	#6 flat fiber washer
253-2	1	#6 shoulder fiber washer
253-10	5	Control flat washer
253-20	2	13/32" ID x 3/4 OD washer
254-1	27	#6 lockwasher
254-2	4	#8 lockwasher
254-3	2	#10 lockwasher
254-4	8	Control lockwasher
255-1	1	#6 x 1/8" spacer
255-6	7	#6 x 1 1/8" spacer
259-1	9	#6 solder lug

PART No.	PARTS Per Kit	DESCRIPTION
Wire		
89-1	1	Line cord
340-2	1	length Bare wire
343-2	4	length Coaxial cable
344-1	1	length Hookup wire
345-1	1	length Braid
346-1	2	length Spaghetti
346-2	1	length 3/16" Spaghetti
Controls-Switches		
10-31	1	10 KΩ sweep width
10-33	1	200 Ω fine attenuator
19-11	1	100 KΩ w/switch hor. phase
19-19	1	200 Ω w/switch marker amp.
63-70	1	3-pos. attenuator
63-82	1	4-pos. band
Transformers-Coils-Chokes		
40-52	1	Marker oscillator coil
45-2	1	RF choke
45-6	2	28 μh choke
46-9	1	30 h filter choke
54-5	1	Power transformer
100-M45	1	750 Ω ww ferrite core choke
403-2	1	Controllable inductor
Chassis Parts-Knobs		
90-24	1	Cabinet
100-M46	2	Pointer knob
200-M68	1	Chassis
203-65F85	1	Panel
204-M57	1	Switch bracket
204-M74	1	Reinforcing bracket
205-M27	1	Shield plate
211-1	1	Handle
462-19	6	Knob
Grommets-Clips-Connectors		
73-1	3	Rubber grommet
260-1	4	Alligator clip
261-1	4	Rubber feet
427-2	4	Binding post base
432-1	1	Cable connector
432-3	2	Connector
438-M8	6	Banana plug
Miscellaneous		
413-1	1	Pilot light jewel
455-1	1	Pilot light bushing
455-6	2	Panel bushing
595-92	1	Manual



A TYPICAL ALIGNMENT SET-UP

Figure 21

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THE WORLD'S *Finest* TEST EQUIPMENT IN KIT FORM